Tele-presence and Operation with Delays

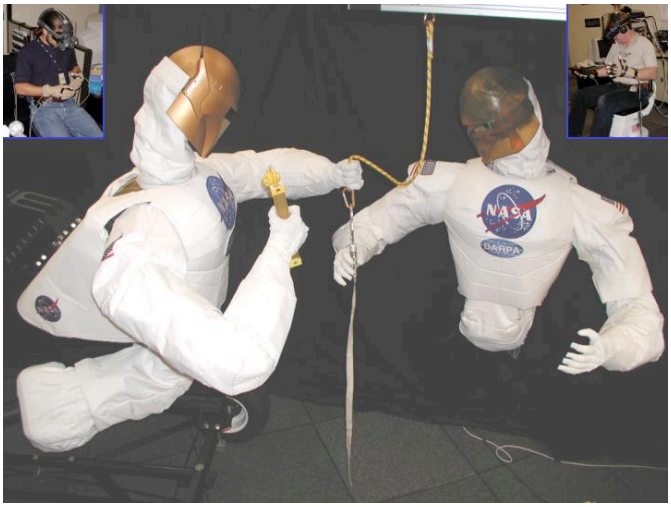
This research specializes in developing methods to predict tele-operator intentions, and then uses these predictions to generate and send automated robotic command sequences.

Background

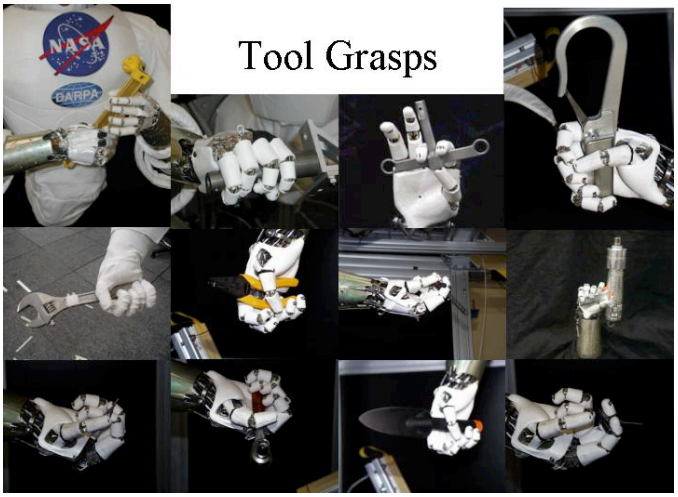
In a partnership between NASA Ames Research Center and NASA Johnson Space Center, we have been investigating methods and developing algorithms for predicting the intentions of tele-operators to compensate for time delays associated with the operation of remote devices. Once the intentions of a tele-operator have been predicted, the sequence of commands that the tele-operator would have needed to generate are then transmitted to the remote device. The status of this device is monitored and the virtual representation presented to the tele-operator is updated accordingly. The anticipated result of this work will be a macro-gesture tele-operation language so that goal-level tele-operation commands may be used instead of low-level device commands.

The research team consists of machine learning researchers and algorithm developers led by Dr. Kevin Wheeler at NASA ARC, and the Robonaut team led by Dr. Robert Ambrose at NASA JSC. This platform has been targeted because it has has many degrees of freedom of movement associated with its fully articulated humanoid hands and arms. This makes tele-operation extremely challenging.

Current research is focused on developing applications in the area of surface construction using Robonaut. The technology developed here is also applicable to other platforms and devices.



Tele-operation of Robonauts A and B at NASA JSC.



Tools grasps with Robonaut hand.

Research Overview

Initial investigations in developing a tele-operator intention prediction interface have focused upon simple experiments measuring hand shape before grasping an object. Our results indicate that it is possible to predict which object a subject is reaching for well before grasp. This concept will then be extended to develop predictions for more complex movements associated with construction tasks.

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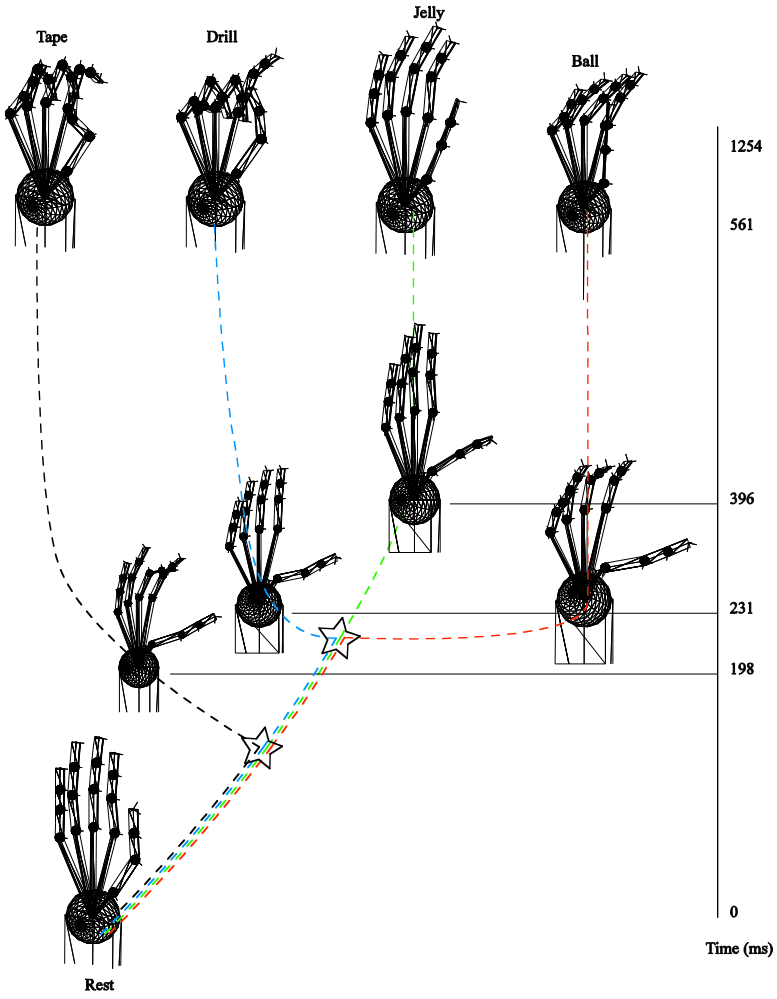

Experiment in grasping for four different objects as represented by joint angles measured using a Cyber-glove. The hand starts in a rest position at the bottom of the figure. Over time it is possible to predict either the object or type of objects that are intended to be grasped. Hidden Markov models for each set of movements were developed and then used to perform this prediction.

Relevance to Exploration Systems

Telepresence control and supervision of highly dexterous robots such as Robonaut over long distances incur a multitude of problems that can be solved with a focused R&D effort that will benefit a much wider range of robotic systems. Factors, such as time delays, situational awareness, robotic state, control reflexes and task context, must be addressed to provide the ability to project oneself into the robotic environment. This project advocates the development of a set of graphical overlays, perception, and telepresence immersion hardware which will convey the robot's state and see its "memory", giving the remote human insight into what the robot understands, in its own terms. Highly dexterous robots will have the ability to sense their environment, identify tools, and observe humans in the shared workspace, reasoning about actions by monitoring dialog to improve perception of its human teammates.

Realistically, teleoperation can handle maximum time delays of no more than 10 seconds, allowing for operations on the moon (depending on the placement of the human operator). Technologies for supervised autonomy and goal level commanding will handle these delays and position the technology for the longer delays of a Mars mission. For the purpose of this proposal, fixed, as well as, variable time delays will be induced into the data transmissions during teleoperation of the robot.

H&RT Program Elements:

This research capability supports the following H&RT program /elements:

ASTP/Software, Intelligent Systems & Modeling

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